DEC STD 187-0 Mechanical Fabrication Workmanship Standards

DOCUMENT IDENTIFIER: A-DS-EL00187-00-0000 Rev A1, 19-Mar-1990

ABSTRACT: This manufacturing standard specifies end-product criteria for Digital-designed fabricated metal or non-metal parts that have been manufactured by or purchased for Digital Equipment Corporation.

APPLICABILITY: This standard specifies workmanship standards for Digital-designed metal and non-metal parts. It is intended to supplement engineering drawings by providing specific information not included on all drawings. This standard will be reference on purchase orders for 70- and 74-class parts, and Digital- designed 12-class parts.

STATUS: APPROVED 30-Mar-1990; use VTX SMC for current status.

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1 INTRODUCTION

1.1 PURPOSE

This manufacturing document specifies end-product criteria for Digital-designed metal and non-metal fabricated parts either manufactured or purchased by Digital Equipment Corporation.

1.2 SCOPE

This document specifies workmanship standards for Digital-designed fabricated metal and non-metal parts. It is intended to supplement engineering drawings by providing specific information not included on all drawings. This document will be referenced on purchase orders for 70- and 74-class parts, and Digital-designed 12-class parts.

1.3 RESPONSIBILITIES

1.3.1 Metals Standards Committee

The Metals Standards Committee is responsible for the content of this specification, and the members of this group must review and approve all proposed changes. Send all comments and proposed changes to Dave Nevala, LTN2-2/D14 , DTN: 226-6577.

1.3.2 Internal Metal Fabricators

All internal organizations that fabricate metal for Digital must comply with the requirements of this standard, unless otherwise specified by the applicable engineering drawing.

1.3.3 Suppliers

Vendors under contract to fabricate Digital-designed metal or non-metal parts must comply with the requirements of this standard to the extent defined in the purchase documents.

2 GENERAL REQUIREMENTS

Whether fabricated in Digital manufacturing facilities or purchased from qualified suppliers, all fabricated parts shall meet or exceed all applicable requirements of this standard, except where superseded by related Digital drawings and specifications. The qualifier "unless otherwise specified" applies to this entire document. General requirements applicable to various parts of this publication and not included in those parts, are listed in the following paragraphs.

2.1 NON-CONFORMING MATERIALS

2.1.1 Non-Conforming Materials at Vendor's Site Before Shipment

Any material, part, or product in which one or more of the characteristics does not conform to the requirements specified in the Digital purchase specification, drawing, or other applicable product description shall be considered to be non-conforming material. Before shipment, such material must be described on a Digital Vendor Material Deviation Request form (obtainable from the Digital purchasing agent), which is to be submitted to the Digital Material Review Board (MRB) for consideration and possible authorization for shipment. Such consideration shall be processed according to Digital Engineering Specification A-SP-7665340-0-0.

2.1.2 Non-Conforming Materials at Digital Incoming Inspection

Non-conforming material received at Digital incoming inspection shall be processed in accordance with Digital Engineering Specification A-SP-7665075-0-0.

2.2 CONTAMINATION

Any contamination, such as rust, excessive oil, grinding dust, chips, or other foreign material, must be eliminated before shipment.

2.3 FLAWS AND DEFECTS

All parts, assemblies, etc., shall be inspected for visual flaws and for visible deviations from the requirements of this specification.

2.4 MEASUREMENT EQUIPMENT

All measurement and calibration equipment must have a periodic re-inspection procedure, and all calibrations shall ultimately be based on the Standards maintained by the National Bureau of Standards. Wear allowance for gauges shall be well within the tolerance of the parts they are to be used to measure.

2.5 DIMENSIONS

Dimensioning shall be in accordance with ANSI Y14.5, *Dimensioning and Tolerancing*. Wherever possible, dimensions are to be measured in the free state of the part. Exceptions (if any) will be specified on the engineering drawing, the purchase specification, or the inspection procedure.

2.6 PACKAGING AND SHIPPING

Packaging and shipping shall be in accordance with good commercial practice, to avoid damage. Special packaging requirements for delicate products must be described on the engineering drawing, the purchase order, or the purchase specification, and must be mentioned in the inspection procedures. Refer to Digital Packaging Instruction A-SP-3700639-00-0, *General Purpose Metal Parts* for appropriate requirements.

3 SHEET METAL

3.1 SHEET METAL FABRICATION

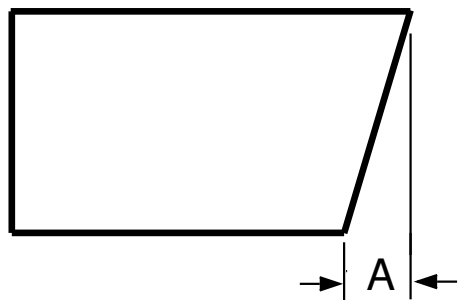
The following paragraphs define general product tolerances and specifications for sheet metal parts, stampings, and wire forms. These requirements shall be observed unless otherwise stated by the engineering drawing, purchase specification, or purchase order. Dimensions and tolerances specified in these paragraphs apply to finished parts, not to raw material.

3.1.1 Shearing

3.1.1.1 Squareness of Cut

To measure the squareness of the cut edge of a blank to its sides, the length is used as the reference and the width must be square within the dimension A, defined as shown in Figure 1. The value of A shall not exceed 0.015 inch per foot of width, to a maximum of 0.032 inch over the entire width.

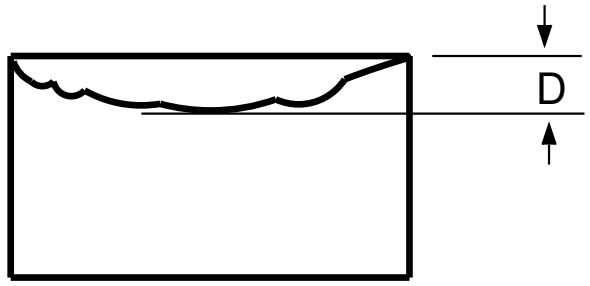
Figure 1: Measuring Squareness of Cut



3.1.1.2 Straightness of Cut

To measure the straightness of a cut edge, the maximum deviation from a theoretical straight edge is measured (D) in Figure 2. D shall not exceed 0.005 inch per foot of length of the cut edge. The measurement shall be made along the shear line, not the fracture line.

Figure 2: Measuring Straightness of an Edge



3.1.1.3 Squareness of Edge

An examination of the cut edge when the metal is sheared will show that the tool cuts the metal straight down for part of its thickness, and then the material fractures for the remainder (B) in Figure 3. While this is obviously not a true square edge, it must be accepted as part of the process. The maximum allowable variation (B) for various material thicknesses is listed in Table 1.

Figure 3: Measuring Squareness of Shear

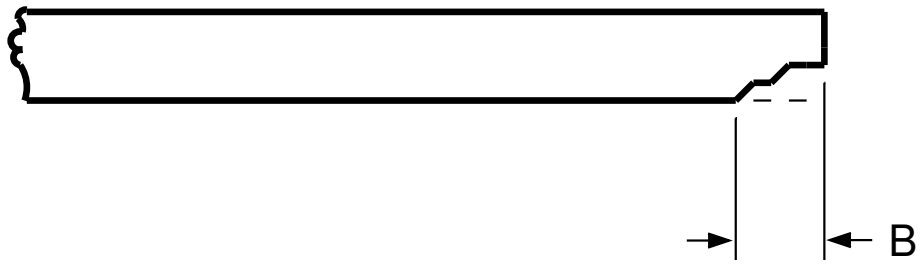


Table 1: Allowable Shearing Fracture Variations

Material Thickness (INCHES)	Maximum Variation (B) (INCHES)
LESS THAN 0.032	0.004
0.32 TO 0.062	0.008
0.063 TO 0.125	0.012
0.126 TO 0.250	0.020
MORE THAN 0.250	0.040

3.1.1.4 Shearing Burrs

All sheet metal parts are to be free from burrs or loose metal chips Figure 4 which might cause interference in assembly, hazard in handling, or possible product failure. Maximum metal displacement beyond the surface intersection shall not exceed the limits listed in Table 2. When the notation "Remove Burrs and Break Sharp Corners" appears on the engineering drawing, the edges shall be broken within the following limits. The radius shall not exceed 0.030 inch, and the chamfer shall not exceed 0.020 inch or 10% of the material thickness, whichever is smaller.

Figure 4: Measuring Burrs

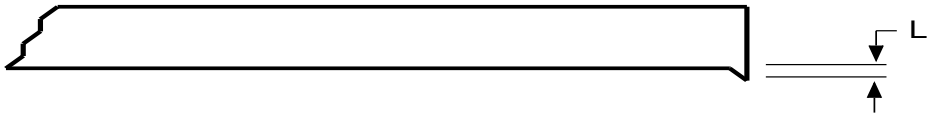


Table 2: Maximum Allowable Burr Length

Material Thickness (inches)	Maximum Burr Length (L) (inches)
Less than 0.016	0.002
0.016 TO 0.032	0.003
0.033 TO 0.062	0.004
0.063 TO 0.125	0.004
More than 0.125	0.004

3.1.2 Flatness of Surface

Flatness of Surface is the extent to which the surface approaches being a true plane. Variations may be in the form of waviness, concavity, or convexity. The tolerance is the distance between two parallel planes within which all bearing points of the relevant surface are located. The tolerance is determined by placing the test material on a true flat surface without clamps or weights Figure 5, and measuring the variation of the material surface from the plane surface. The allowable tolerances (T) for various surface areas and material thicknesses are listed in Table 3.

Figure 5: Measuring Surface Flatness

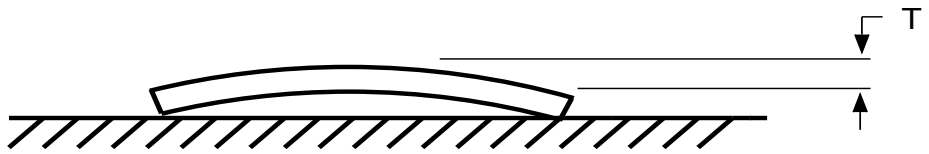


Table 3: Surface Flatness Tolerance

Material Thickness	Surface Area (in square inches)				
(inches)	1-4	5-49	50-199	200-1000	Over 1000
Less than 0.0156	0.010 inch	0.020 inch	0.035 inch	0.050 inch	0.060 inch
0.0156 to 0.0469	0.010 inch	0.020 inch	0.035 inch	0.040 inch	0.050 inch
0.0470 to 0.0624	0.008 inch	0.015 inch	0.025 inch	0.030 inch	0.040 inch
0.0625 to 0.0937	0.005 inch	0.010 inch	0.020 inch	0.025 inch	0.030 inch
0.0938 to 0.1249	0.005 inch	0.008 inch	0.020 inch	0.020 inch	0.025 inch

3.1.3 Bending

3.1.3.1 Right Angle Bends

Angles not specified on engineering drawings should be assumed to be 90° with a tolerance of ±30 minutes Figure 6. The tolerance (E) will vary according to the material thickness, hardness, etc. For mild steel, the average variations allowable are listed in Table 4.

Figure 6: Right Angle Bend Tolerance

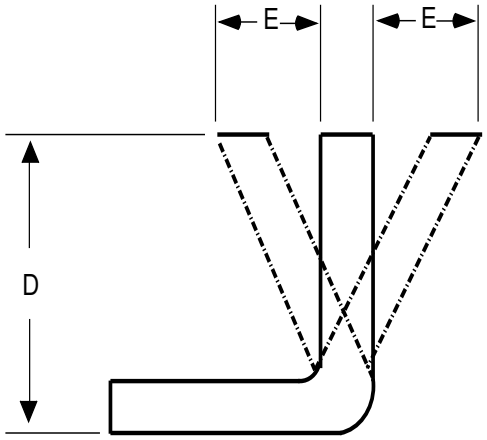


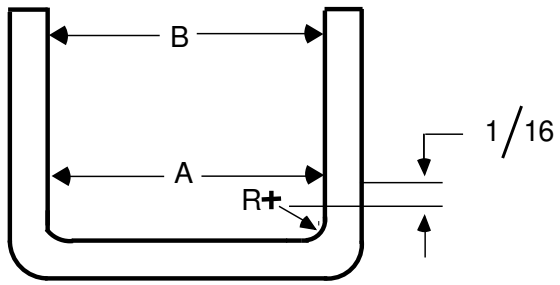
Table 4: Right Angle Bend Tolerances for Mild Steel

Bend Length (D) (inches)	Tolerance (E) (inches)
Under 0.5	0.005
0.5 to 1.5	0.010
1.5 to 6	0.015
6 to 12	0.030

3.1.3.2 U-Shaped Bends

Unless otherwise specified on an engineering drawing, dimension (A) of Figure 7 shall be measured 1/16 inch above the tangent point of the radius. The end of the jaws, dimension (B), shall be (A ± 2E), where (E) is defined as in paragraph 3.1.2.1 and Figure 6.

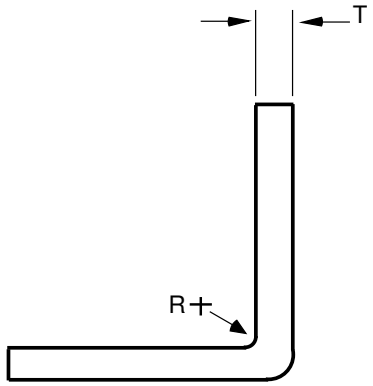
Figure 7: U-Shaped Bend Tolerance



3.1.3.3 Bend Radii

Unless specified otherwise by the engineering drawing, all angles shown square on the drawing shall have a minimum inside bend radius (R) equal to the material thickness (T) or 0.030 inch, whichever is greater Figure 8. This is in accordance with standard industry practice to avoid material delamination and surface cracks due to bending force.

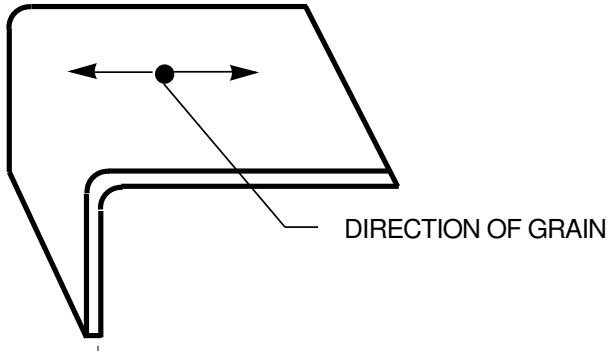
Figure 8: Bending the Material



3.1.3.4 Bending Damage

Fractures or cracks at the bend are unacceptable. Wherever possible, bend perpendicular to the direction of the grain, as shown in Figure 9.

Figure 9: Bending Across the Grain



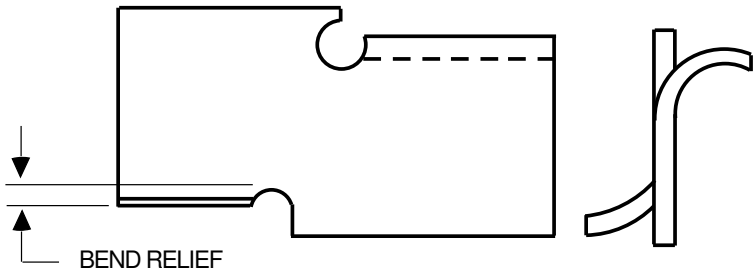
3.1.3.5 Flaring

Flaring of metal at a bend is acceptable, provided it does not exceed 25% of the material thickness, and provided there is no crack in that portion of the material.

3.1.3.6 Bend Relief

Where flanges extend over only a portion of a part, a notch or hole should be provided to prevent tearing as shown in Figure 10. The minimum recommended bend relief equals the sum of the material thickness and the bend radius.

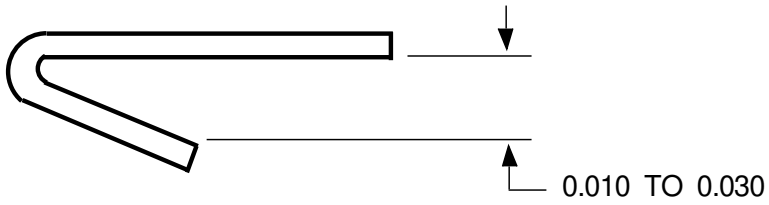
Figure 10: Notching for Bend Relief



3.1.3.7 Hemming

When hemming (bending 180°), a gap must be allowed to permit cleaning the part. Unless otherwise specified, a gap of 0.010 inch to 0.030 inch shall be provided. See Figure 11.

Figure 11: Hemming Clearance



3.1.4 Punching Holes

Punched holes may have flanges as in Figure 12, or may be without flanges as in Figure 13. The default tolerance block on Digital engineering drawings does not apply to hole tolerance. Standard hole tolerances shall be as described in paragraph 4.1.8.

For punched holes, maximum burr length shall depend on the material thickness and shall be in accordance with Table 2. Punched holes shall be measured in the sheared or non-breakaway section of the wall. They are acceptable if they are within the tolerance specified, and if not more than 33% of the hole wall is torn or broken away.

Punched holes requiring fits for inserts, studs, etc., shall have the tolerance indicated on the Digital engineering drawing.

Figure 12: Punched Hole with Flanges

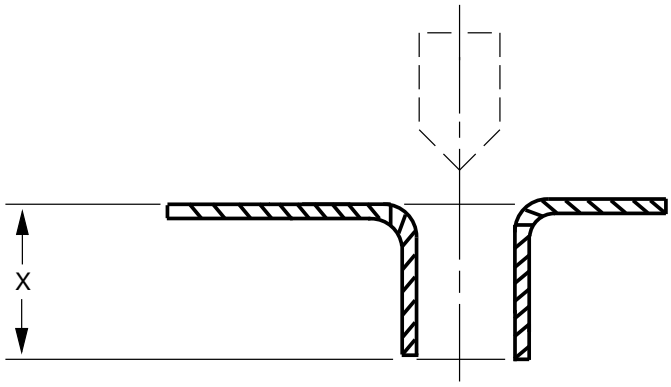
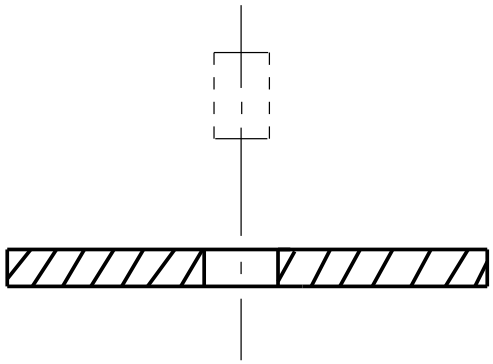


Figure 13: Punched Hole without Flanges



3.1.4.1 Material Thickness Versus Hole Size

By common practice, minimum hole size is usually limited to 75% of the stock thickness.

3.1.4.2 Distance of Punched Hole From Edge of Blank

To avoid distortion in sheet metal, holes must not be too close to an edge. For sheet metal 1/32 inch or less in thickness, all holes should be at least 1/16 inch from the nearest edge. For thicker metal, the minimum distance from an edge should be twice the thickness, but not less than 1/8 inch. The minimum distance between two punched holes should be at least twice the thickness of the sheet metal.

If the holes are to have inserts, studs, etc. pressed in, the manufacturer's recommendations for minimum distances should be obeyed.

3.1.4.3 Distance of Punched Hole From Bend

The minimum inside dimension from a bend to the edge of a punched hole should be 1.5 times the sum of the material thickness and the bend radius.

3.1.4.4 Minimum Flange (Bent Length) Dimensions

The minimum recommended flange dimensions should be at least 3.5 times the sum of the material thickness and the bend radius. Whenever possible, the flange should be at least 0.38 inch in length.

3.1.4.5 Tapped Drawn Hole

Flanged holes to be tapped require material of adequate ductility. The tolerance for the (C) dimension of Figure 14 is ±0.020 inch. Appropriate values of (C) are listed in Table 5.

Figure 14: Tapping a Flanged Hole

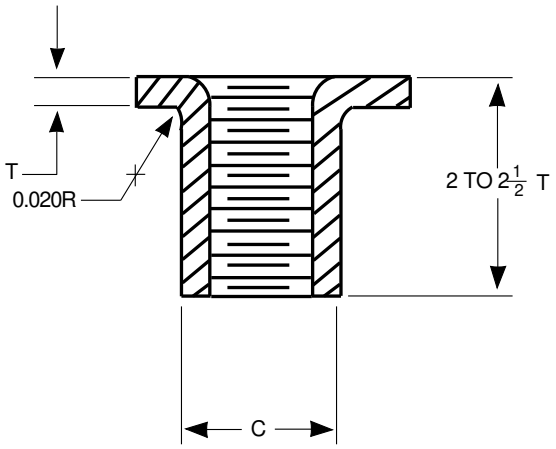


Table 5: Flange Diameters for Tapping

Material Thickness (inches)	Tap Size (inches) 6-32	Tap Size 8-32	Tap Size 10-32
Pre-Tap Inside Diameter	0.122	0.148	0.174
0.045	0.158	0.185	0.214
0.050	0.163	0.190	0.218
0.063	0.173	0.200	0.225

3.2 STAMPING

Stamping is the working of sheet metal with a press to change its shape, with or without accompanying shearing or punching. All sheet metal fabrication requirements apply, in addition to the following paragraphs.

3.2.1 Stock Thinning

Reduction of the thickness of the stock is permitted, provided the thinning does not exceed 25% of the nominal stock thickness.

3.2.2 Stock Thickening

Stock thickening is permissible, provided it does not exceed a 15% increase beyond the nominal stock thickness.

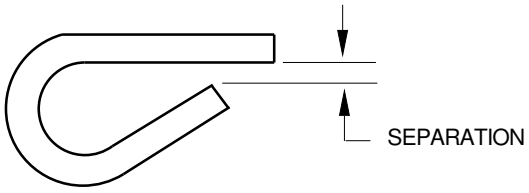
3.3 WIRE FORMING

Wire forming is a method of constructing parts or assemblies from various types of wire and wire shapes, as substitutes for conventional sheet metal fabrications, stampings, castings, etc. The principal wire fabrications for wire-formed assemblies are eyes, bends, swaging and piercing, rings and ring segments, threading, and weldments.

3.3.1 Eyes

Eyes can be formed in the ends of wires; tear-drop eyes cost less to form than round eyes. Eyes can be either centered with respect to the wire's centerline or offset. Ends of eyes may be separated from main sections by 25% of the wire diameter. Figure 15 illustrates an offset teardrop eye, with separation.

Figure 15: Measuring Separation in an Offset Teardrop Eye



3.3.2 Bends

In general, the minimum bending radius should be equal to the diameter of the wire. Bending tolerances are specified in subhead 3.1.2.1.

3.3.3 Swaging and Piercing

Flattened areas at wire ends or mid-sections can be obtained by swaging to provide a surface for piercing of a hole. See subheads 3.1.3

and 3.2.1 for appropriate tolerances.

3.3.4 Shearing and Shearing Burrs

Shearing of wire ends shall be in accordance with the requirements of paragraphs 3.1.1.3 and 3.1.1.4.

3.3.5 Threading

Threads may be either cut or rolled on wire ends. See Tables 10 and 11 for dimensions and tolerances on threaded wires.

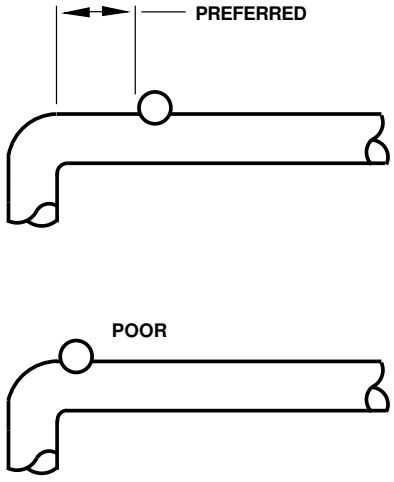
3.3.6 Welding

Resistance (spot) welding is the preferred method of fabrication. Arc welding and gas welding can also be used, but are slower and more expensive. See 8.4 and subordinate subheads for information on acceptability of welds.

3.3.6.1 Cross-Wire Welding

Cross-wire welding is the most common method used for joining wire forms. Avoid welding one wire on the bend radius of another. See Figure 16.

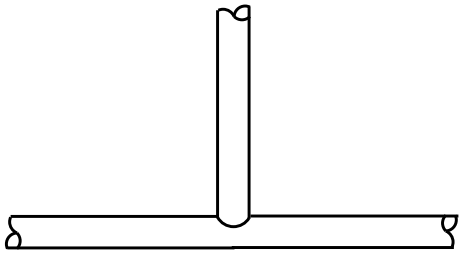
Figure 16: Cross-Wire Welding



3.3.6.2 T Welding

A straight piece of wire can be welded into the side of another, as shown in Figure 17. A special fixture is used.

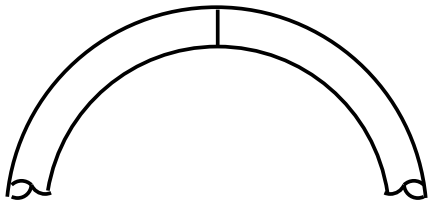
Figure 17: T Welding



3.3.6.3 Butt Welding

The flash extruded in welding is normally left on the part when the ends of wire rings, loops, rectangular frames, etc. are welded together to produce a closed piece, as shown in Figure 18. Unless otherwise specified, this is acceptable so long as it does not exceed 10% of the wire diameter.

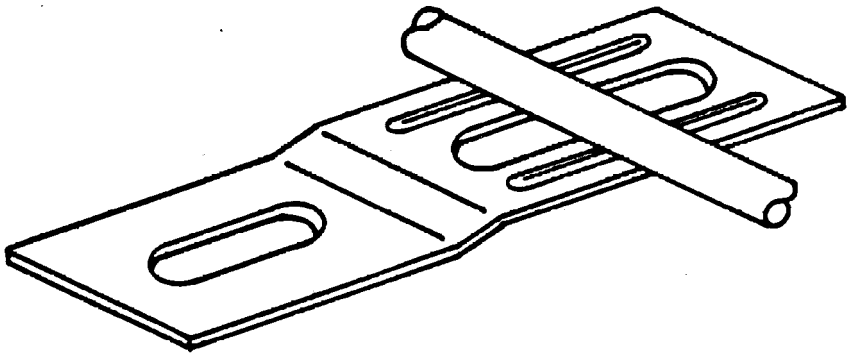
Figure 18: Butt Welding



3.3.6.4 Projection Welding

To obtain reliable welds when joining wire to strip steel or tubing parts, weld projections should be formed in the part to be joined to the wire to concentrate the welding current at the point of weld, as shown in Figure 19.

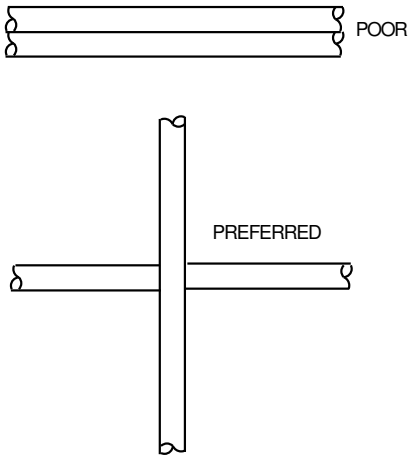
Figure 19: Projection Welding



3.3.6.5 Line Welding

Parallel wires can be welded along their length, but this type of weld should be avoided where possible. Figure 20 illustrates both methods.

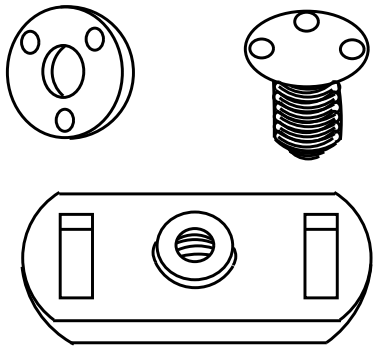
Figure 20: Line Welding



3.3.6.6 Weldments

Many types of nuts, studs, and washers can be projection-welded to wire assemblies. Figure 21 shows several types.

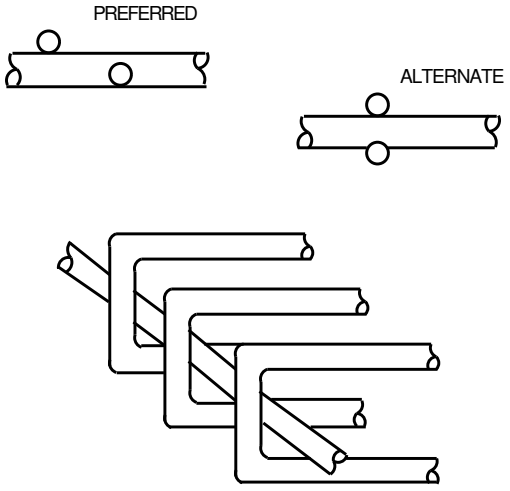
Figure 21: Weldments



3.3.6.7 Sandwich Welding

Figure 22 illustrates preferred and alternate methods of sandwich welding.

Figure 22: Sandwich Welding



4 MACHINING

The following subheads apply to finished dimensions only, not in-process dimensions. Included are important machining standards for cutting, boring, drilling, grinding, lapping, turning, and threading.

4.1 GENERAL MACHINING

4.1.1 Machining Burrs

Unless otherwise specified, burrs resulting from machining operations shall be removed. Breaking or rounding an edge shown as square on a drawing shall be in accordance with paragraph 4.1.2.

4.1.2 Break Sharp Edges

When specified by the engineering drawing, edges shall be broken, within the following limits. The radius shall not exceed 0.030 inch; the chamfer shall not exceed 0.020 inch or 10 percent of the material thickness, whichever is smaller.

4.1.3 Inside Corners

An inside corner shown as square on a drawing shall not have a radius larger than 0.010 inch, except that a radius of 0.015 inch is permissible for stainless steel.

4.1.4 Flatness

Machined surfaces shall be flat within 0.0005 inch/inch or within 0.005 inch total, whichever is larger.

4.1.5 Straightness

Machined edges of surfaces shall be straight within 0.0005 inch/inch or within 0.005 inch total, whichever is larger.

4.1.6 Parallelism and Squareness

Machined surfaces and edges shall be parallel and square within 0.0005 inch/inch or within 0.005 inch total, whichever is larger.

4.1.7 Counterbored Holes

Unless otherwise specified, the tolerance on counterbored holes shall be as shown in Table 6.

Table 6: Tolerance for Counterbored Holes

Hole Diameter (inches)	Diameter Tolerance (inches)	Depth Tolerance (inches)
Less than 0.126	+0.005, -0.004	+0.005
0.126 to 0.250	+0.007, -0.005	+0.006
0.251 to 0.500	+0.008, -0.006	+0.007
0.501 to 0.750	+0.009, -0.007	+0.007
0.751 to 1.500	+0.012, -0.010	+0.010

4.1.8 Hole Tolerances

The engineering drawing tolerance block does not cover drilled, punched, machined, or molded holes. Unless the drawing specifically lists hole tolerances, the tolerances of Table 7 apply.

Table 7: Hole Tolerances for Various Materials

Hole Diameter (inches)	Hole Tolerances(inches) Metal	Hole Tolerances(inches) Non-Metal	Hole Tolerances(inches) Molded Plastic
Less than 0.041	+0.004, -0.003	+0.004, -0.003	+0.003
0.041 to 0.070	+0.004, -0.003	+0.004, -0.004	+0.003
0.071 to 0.128	+0.006, -0.003	+0.005, -0.005	+0.004
0.129 to 0.228	+0.006, -0.003	+0.005, -0.006	+0.004
0.229 to 0.500	+0.006, -0.005	+0.004, -0.007	+0.005
0.501 to 0.750	+0.008, -0.005	+0.005, -0.008	+0.005
0.751 to 1.000	+0.010, -0.005	+0.005, -0.010	+0.010
1.001 to 3.000	+0.015, -0.010	+0.010, -0.015	+0.015
3.001 to 6.000	+0.020, -0.010	+0.010, -0.020	+0.015
Over 6.000	+0.030, -0.010	+0.010, -0.030	+0.020

4.1.9 Machined Surface Quality

Surface quality of a machined surface shall be measured in accordance with ANSI Standard B46.1, and shall be expressed as the arithmetical average of a series of Roughness Height measurements, stated in micro-inches (millionths of an inch). Figures 23 and 24 explain many of the terms used in the field of machined surface quality measurement. A roughness width cutoff of 0.030 shall be used as standard, unless otherwise stated. Scratches, ridges, cracks, and other random surface flaws shall not be considered in evaluating average texture. The use of Root Mean Square (RMS) values is obsolete; RMS will no longer be used. When RMS values were used, the figures obtained were approximately 11% higher than the figures obtained using the present arithmetic average.

Dimensional tolerance and roughness height (surface finish) are related; therefore, if the arithmetical average of surface roughness specified exceeds the values shown in Table 8, the total tolerance may be taken up by the roughness height. When not otherwise specified on the drawings, the following maximum finishes for metal parts apply.

Figure 23: Surface Roughness Entities

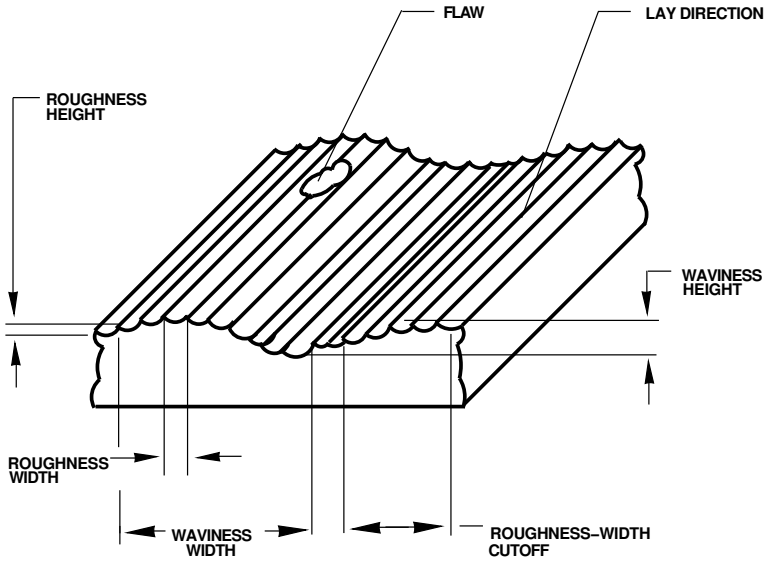


Figure 24: Calculating Surface Roughness

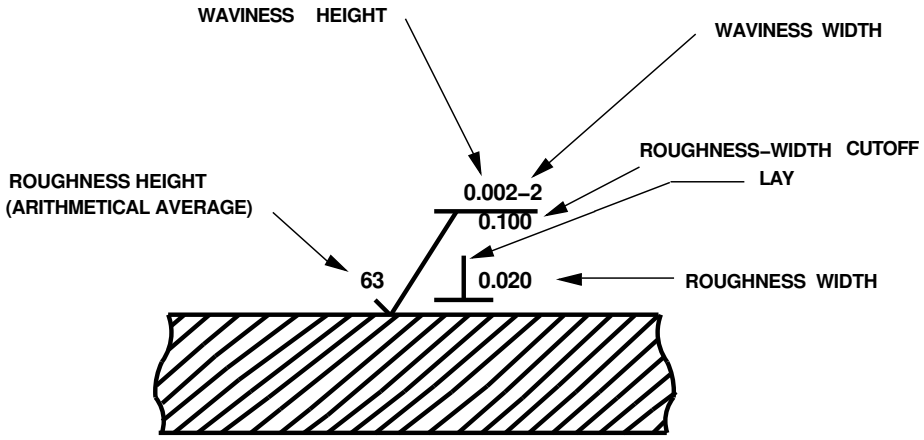


Table 8: Acceptable Machined Surface Roughness Levels

Total Tolerance (inches)	Roughness	Finish Description
	250	Roughing operations - machine marks may show.Not acceptable as a finished machine surface.
More than 0.005	125	Normal machine finish - light tool marks may show.
0.002 to 0.005	63	Medium machine finish - fine tool marks may show.
0.0005 to 0.002	32	Fine machine finish - smooth surface.
Less than 0.0005	16	Fine grind extra smooth surface.

4.1.10 Grinding

Removal of stock during rough grinding should be 0.005 inch to 0.040 inch. Typical surface finish ranges from 16 to 63 micro-inches of roughness.

Removal of stock during finish grind should be 0.0002 to 0.002 inch. Typical surface finish ranges from 4 to 16 micro-inches of roughness.

4.1.11 Lapping

Lapping creates an extremely smooth and accurate surface by rubbing. Typical surface finish ranges from 2 to 16 micro-inches with minimal stock removal.

4.1.12 Honing

Honing is similar to lapping, except that a stone is used. Surface quality ranges from 4 to 32 micro-inches with minimal stock removal.

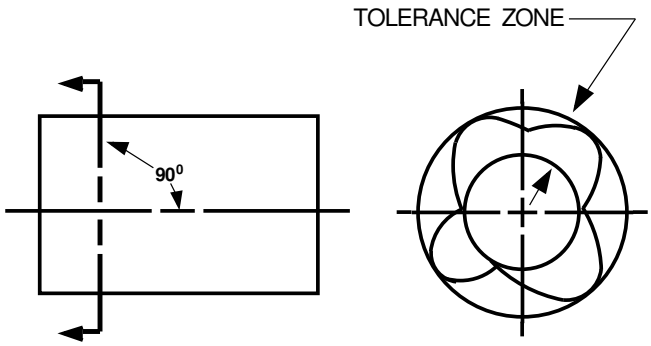
4.2 MACHINING OF CYLINDRICAL FORMS

This and subordinate subheads discuss the principal considerations in machining cylindrical forms. They are out-of-roundness, straightness, cylindricity, and runout.

4.2.1 Roundness

A roundness tolerance specifies a tolerance zone bounded by two concentric circles within which each circular element of the surface must lie, and applies independently at any plane. Unless otherwise specified, it should not exceed the total tolerance for that dimension or 0.005 inch Total Inches of Roughness, whichever is smaller. Figure 25 shows this configuration.

Figure 25: Measurement of Roundness



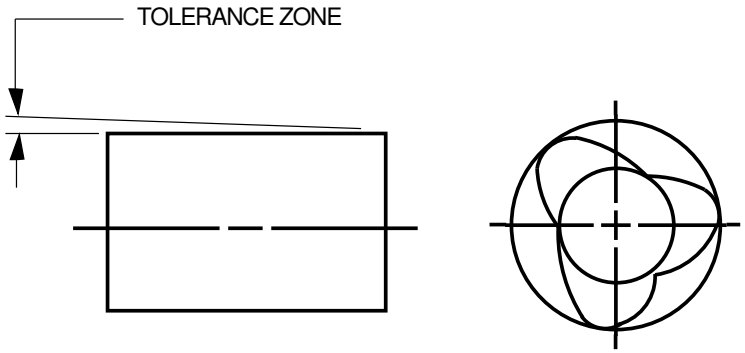
4.2.2 Straightness

Machined edges of surfaces shall be straight within 0.0005 inch/inch or within 0.005 inch total, whichever is larger.

4.2.3 Cylindricity

Cylindricity is a combination of roundness, straightness, and parallelism of a cylindrical feature. A cylindricity tolerance specifies a tolerance zone bounded by two concentric cylinders within which the surface must lie. In the case of cylindricity, unlike that of roundness, the tolerance applies simultaneously to both circular and longitudinal elements of the surface (the entire surface). The cylindricity tolerance, unless otherwise specified, should not exceed the total tolerance for that feature or 0.005 inch Total Inches of Roughness, whichever is smaller. Figure 26 shows this configuration.

Figure 26: Measurement of Cylindricity



4.2.4 Runout

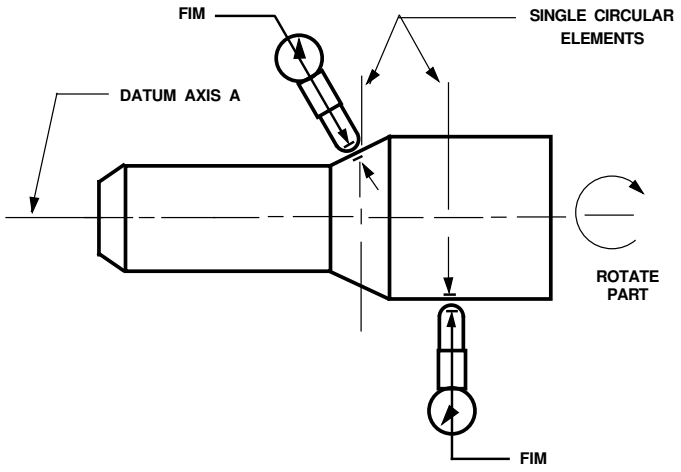
Runout is a composite tolerance used to describe the functional relationships of one or more features of a part to a datum axis. Runout describes cumulative variations of form and location characteristics such as roundness, straightness, concentricity, angularity, taper, and profile of surface. Where applied to surfaces constructed at right angles to a datum axis, runout describes cumulative variations of characteristics such as perpendicularity, and flatness.

There are two types of runout, circular runout and total runout. Unless otherwise specified, the runout will be assumed to be circular, and should not exceed the total tolerance for that dimension or 0.005 inch, whichever is smaller.

4.2.4.1 Circular Runout

Circular runout provides composite measurement of circular elements of a surface. The tolerance is applied independently at any circular measuring position as the part is rotated 360°. Figure 27 illustrates this procedure.

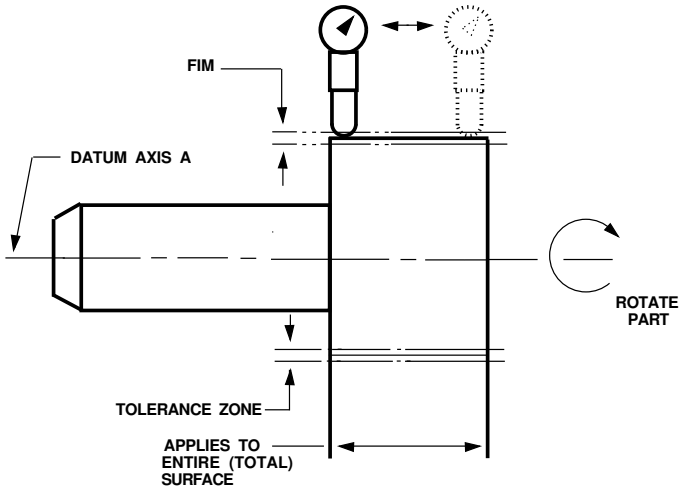
Figure 27: Measuring Circular Runout



4.2.4.2 Total Runout

Total runout provides composite measurement of all surface elements. The tolerance is applied simultaneously to all circular and profile measuring positions as the part is rotated 360°. Figure 28 shows this procedure.

Figure 28: Measuring Total Runout



4.2.5 Clearance and Stress Relief

Unless otherwise noted on the engineering drawing, clearance relief is required on inside corners of cylindrical parts. The configuration shown in Figure 29 is to be used when the diameter is to be precision- machined to a close tolerance. The relief depth (B) and the relief width (C) are shown in Figure 29. Table 9 lists appropriate values of (B) and (C) for various finished diameters. The stress relief radius (R) should be at least 0.015 inch.

If both the diameter and face are to precision-machined, the relief configuration shown in Figure 30 should be used.

Figure 29: Clearance Relief for a Cylinder with a Machined Diameter.

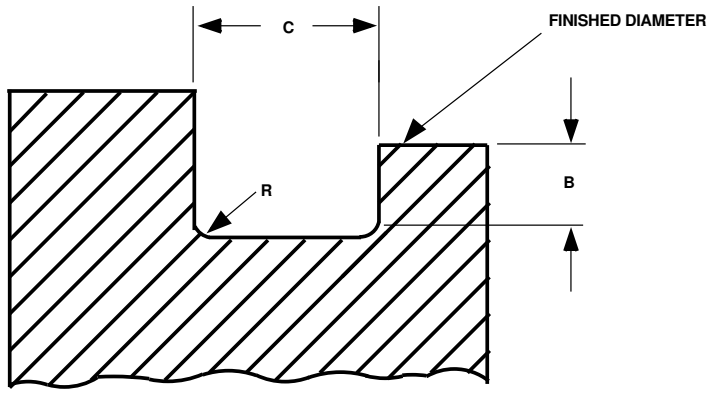


Figure 30: Clearance Relief for a Cylinder with a Machined Face and Diameter.

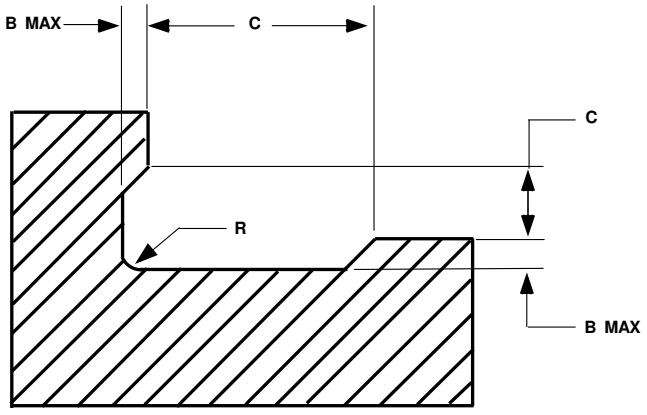


Table 9: Relief Depth and Width for Machined Cylinders

Finished Diameter or Length (inches)	Maximum Relief Depth (B) (inches)	Relief width (C) (inches)
Less than 0.251	0.006	0.05
0.251 to 0.500	0.010	0.05
0.501 to 1.000	0.015	0.09
More than 1.000	0.030	0.125

4.2.6 Tool Center Holes

Tool center holes are acceptable unless prohibited on the engineering drawing. The preferrable included angle shall be 60° and the maximum diameter shall not exceed 25% of the surface diameter.

4.3 MACHINING OF THREADED PARTS

This and subordinate subheads cover the machining of screws and threaded holes, including screw forms, bars, rods, and spindles. Accepted standard practice for threads, unless otherwise noted on the engineering drawing, is as follows:

a. If threads are to be righthand, Class 2A for external and 2B for internal, they shall be in accordance with ANSI B1.1.

b. Tapped holes shall have a minimum of 75% full thread.

c. All threads shall be free from burrs, nicks, and chattered surfaces that would interfere with function.

d. All internal threads not otherwise specified shall be countersunk at the entrance at 82° ± 10° to the root diameter for straight threads, and 90° ± 10° for pipe threads.

e. All external threads not otherwise specified shall exhibit an entering end chamfered 45° ± 5° to the thread depth.

f. Dimensions of thread length shown on engineering drawings are for perfect threads; there may be as many as three imperfect threads beyond the indicated depth.

g. Thread relief, as shown in Figure 31, is necessary for ease of manufacture of screw forms. Stress relief is also provided in the process by rounding the corners. Unless otherwise specified on the drawing, thread and stress reliefs should be as shown in Table 10. Reliefs for thread sizes not included in Table 10 may be computed by using the following dimensions. For A, use the width of 2 .5 threads. For B, use the minor diameter minus 0.010 inch (for threads not greater than 0.250 inch), minus 0.020 inch (for threads nominally 0.250 to 0.625 inch), or minus 0.030 inch (for threads greater than 0.625 inch). For C, use 0.010 inch (for threads not greater than 0.250 inch), 0.020 inch (for threads no minally 0.250 to 0.500 inch), or 0.030 inch (for threads greater than 0.500 inch).

Figure 31: Screw Thread Relief

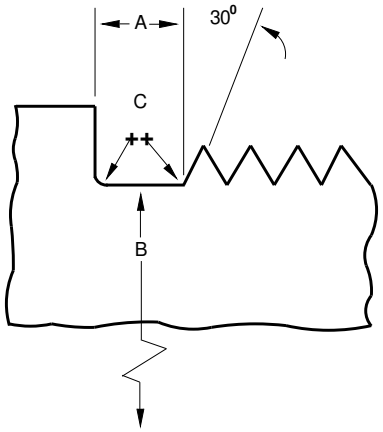


Table 10: Thread Relief Dimensions

Thread Size	Maximum A (inches)	Minimum B (inches)	Minimum C (inches)	Basic Major Dia. (inches)	Minimum Major Dia. (inches)
0-80	0.031	0.034	0.010	0.0600	0.0563
2-56	0.045	0.054		0.0860	0.0813
4-40	0.062	0.070		0.1120	0.1061
6-32	0.078	0.089		0.1380	0.1312
8-32	0.078	0.150		0.1640	0.1571
10-32	0.078	0.141		0.1900	0.1831
0.250-20	0.125	0.168	0.020	0.2500	0.2408
0.312-18	0.139	0.223		0.3125	0.3026
0.375-16	0.156	0.277		0.3750	0.3643
0.438-14	0.179	0.328		0.4375	0.4258
0.500-13	0.192	0.384		0.5000	0.4876
0.562-12	0.208	0.439	0.030	0.5625	0.5495
0.625-11	0.227	0.492		0.6250	0.6113
0.750-10	0.250	0.596		0.7500	0.7353
0.875-9	0.278	0.707		0.8750	0.8592
1.000-8	0.312	0.815		1.0000	0.9830

4.3.1 Rolled Threads

Thread rolling is used for high volume production and when extra thread strength is required. The following general rules apply. Rolled-thread screws may be manufactured on a thread rolling machine or an automatic screw machine with a threading roll. Table 11 shows the sizes of blanks to be used.

The rolled thread blank is approximately the pitch diameter of the finished thread. Threads may be conventionally die cut on wire ends when thread size must be exactly the same as the wire size. Typical thread and blank sizes are shown in Table 11.

Table 11: Blank Sizes for Thread Rolling

	Fine Pitch Series		Coarse Pitch Series	
Screw Size	Thread Density (threads/inch)	Blank Size (inches)	Thread Density (threads/inch)	Blank Size (inches)
1	72	0.062		
2	64	0.074	56	0.072
3	56	0.085	48	0.083
4	48	0.096	40	0.093
5	44	0.107	40	0.106
6	40	0.119	32	0.115
8	36	0.143	32	0.141
10	32	0.167	24	0.159
12	28	0.189	24	0.185
1/4	28	0.223	20	0.213
5/16	24	0.282	18	0.272

4.3.2 Screw Thread Gauging Practice

ANSI B1.1 provides detailed coverage of screw thread gauging and conformance to established industry standards.

5 CASTINGS

This and subordinate subheads apply to end product requirements for die castings, sand castings, permanent mold castings, investment castings, and powdered metal parts. In addition, many of the references cited include design and process guidelines which should be considered during part design and tooling. *DEC STD 020* is the *Casting Design and Drafting Standard.* In the event of conflict with this standard, DEC STD 020-0 takes precedence.

5.1 DIE CASTING

Unless specified otherwise on applicable engineering drawings, die castings shall conform to the requirements of the American Die Casting Institute standard *Product Standard for Die Castings.* This standard covers the areas of engineering requirements, metallurgical requirements, commercial requirements, and quality requirements.

5.2 SAND AND PERMANENT MOLD CASTINGS

Requirements for aluminum sand and permanent mold castings, unless specified otherwise on appropriate engineering drawings, will be in accordance with the requirements of the Aluminum Association Incorporated, *Standards for Aluminum Sand and Permanent Mold Castings.* This standard includes engineering requirements and metallurgical requirements. For information on iron castings, refer to DEC STD 020-0 and the Iron Castings Society standard *Iron Castings Handbook.*

5.3 INVESTMENT CASTINGS

Investment casting requirements, unless specified otherwise on engineering drawings, will be in accordance with the standards of the Investment Casting Institute, as documented in the *Investment Casting Handbook.*

5.4 POWDERED METAL PARTS

This is a process by which small metal parts in large quantities can be made by the compressing and sintering of various powdered metals, such as brass, bronze, and iron. Unless otherwise specified, powdered metal parts shall conform to the requirements of *DEC STD 179-0 requirements for Specifying Raw materials for Powder-Metal Parts*.

6 PLASTICS

This and subordinate subheads apply to end product requirements for plastic parts. In addition, the references cited include guidelines which should be considered during design and tooling of plastic parts to produce parts consistently at economic levels. For drafting information, refer to ANSI Y14.11 *American Drafting Standards Manual - Section II Plastics.*

6.1 MOLDING

Unless specified otherwise on applicable drawings, plastic parts shall conform to the requirements of *Standards and Practices of Plastic Molding and Plastic Molded Parts Buyers Guide*, a publication of The Society of the Plastics Industry, Inc. This standard includes engineering requirements, commercial requirements, and a glossary of terms used in the industry.

6.1.1 Color and Surface Finish

The color and surface finish will be in accordance with the finish specifications listed in Table 4-1 of *DEC STD 092,*as modified by the engineering drawing.

6.1.2 Molded Holes

Unless otherwise specified, tolerances for molded holes will be in accordance with Table 8.

6.2 MATERIALS

Material required will be noted on the applicable drawings, along with any special requirements, such as percent of permissible regrind. If regrind is not noted, it is allowed. For properties of materials, refer to the Society of Plastic Industries publication *Plastics Engineering Handbook.*

6.3 FLAMMABILITY

All plastic materials furnished to Digital must meet the minimum requirements of *DEC STD 119-0 Digital Product Safety*, and UL-94, *Standard Tests for Flammability of Plastic Materials for Parts in Devices and Applicances,* and must be certified in accordance with Digital Specification A-SP-ELCE059-TM-002N, *Test Method for Flammable Plastics.*

6.4 IDENTIFICATION

All plastic parts should be permanently identified in accordance with *DEC STD 178-1 Digital marking Requirements for Piece Parts* unless part size or specific use makes this impossible. Multi-cavity molds should have the cavity numbers engraved in the mold. Parts may be identified by engraving the mold or by ink stamping, and should include the part number, revision, and vendor identification.

7 FINISHING

Finishes shall be in accordance with the finish specifications listed in Table 4-1 of DEC STD 092. Unless otherwise specified, dimensions shall apply after the application of inorganic finishes, such as plating, chromates, oxides, etc., but before the application of organic finishes, such as lacquers, varnishes, enamels, etc. Any specified machined surface quality shall apply before the application of any type of finish.

8 ASSEMBLY

This and subordinate subheads describe the requirements for the assembly of parts by riveting, inserting threaded attachments, and welding.

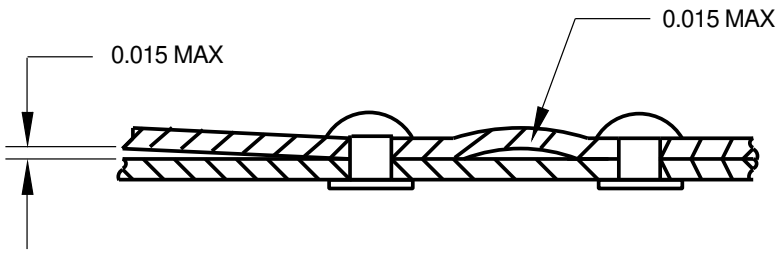
8.1 RIVETING

8.1.1 General

8.1.1.1 Sheet Separation

Sheets shall be pulled together tight at the junction of the rivet shank. Separation between sheets shall not exceed 25% of the thickness of the thinnest sheet being joined or 0.015 inch, whichever is smaller. See Figure 32.

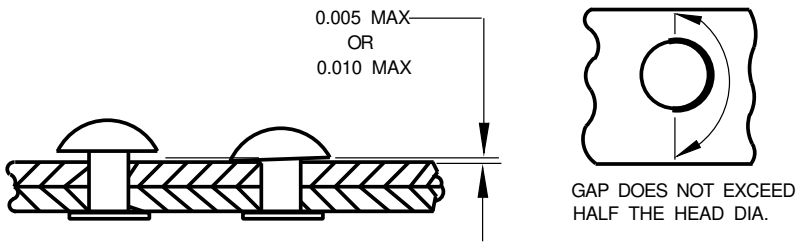
Figure 32: Separation Between Riveted Sheets



8.1.1.2 Head Seating

The preformed heads of rivets shall normally sit flush to the mounting surface. Gaps are allowed up to 0.005 inch for rivet heads less than 1/4 inch in diameter and 0.010 for rivets with heads greater than 1/4 inch in diameter, providing that the gap does not exceed 50% of the head circumference. Figure 33 illustrates acceptable gaps.

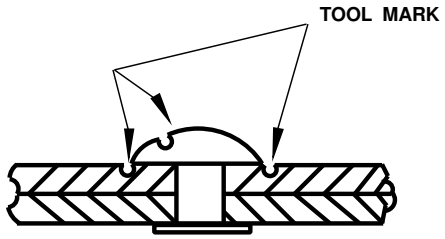
Figure 33: Preformed Rivet Head Gaps



8.1.1.3 Tool Marks And Cracks

Surfaces of joined material and rivet heads should be free of visible cracks or distortion. One radial crack, not extending to the shank and not exceeding 0.010 inch in width, is acceptable. Not more than 10% of the rivets in a joint may contain a crack. Tool marks Figure 34 or indentures in excess of 25% of material thickness or greater than 0.015 inch in depth or width shall not be allowed.

Figure 34: Rivet with Tool Mark



8.1.2 Blind Rivets

Blind rivets refer to hollow rivets assembled with a mandrel which is pulled through and broken off at assembly to permanently set the rivet. Part of the mandrel may or may not be left in the assembly, depending on the particular rivet being used.

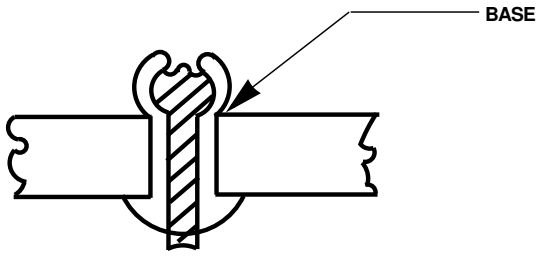
8.1.2.1 Structural Blind Rivets

For basic standards information on structural blind rivets used in the assembly of cabinets, refer to Digital engineering specification A-SP-7665271-0-0, *Cherry "Q" Rivet (Self Plugging) Procedure.*

8.1.2.2 Rollover

Rollover of the post-formed portion of pop rivets shall be uniform and flush all around at the base, and shall be free of any visible cracks Figure 35.

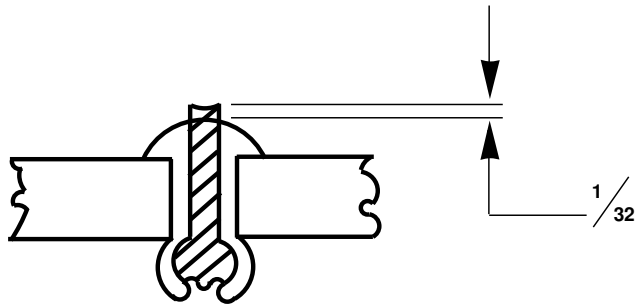
Figure 35: Pop Rivet Rollover



8.1.2.3 Mandrel Height

The height of the broken-off portion of the mandrel shall not exceed the values shown in the appropriate purchase specification. For the structural rivet referenced in paragraph 8.1.2.1 the maximum value is 1/32 inch, as shown in Figure 36.

Figure 36: Height of Broken-Off Mandrel



8.1.3 Flush Rivets

Specifications relating to head seating, sheet separation, and tool marks are contained under subhead 8.1.

Flush peened and countersunk rivets shall not project above the surface; they shall be flush with the surface ±0, ±0.010 inch Figure 37. The rivet should completely fill the countersunk area, although a gap of 0.005 inch is allowed if it does not extend to the shank of the rivet and does not exceed 50% of the rivet circumference Figure 38. The formed area of the flush rivet shall have a minimum width of 1.5 times the rivet shank diameter.

Figure 37: Countersunk Rivet Head Depth

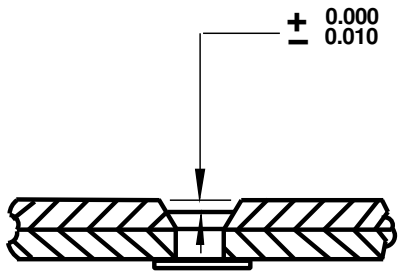
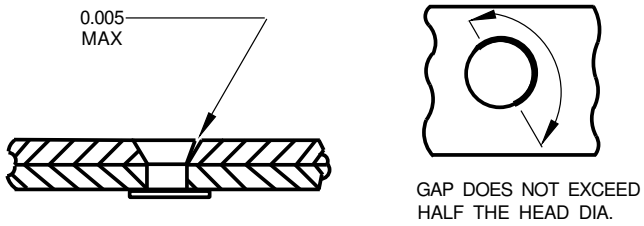


Figure 38: Countersunk Rivet Head Gap



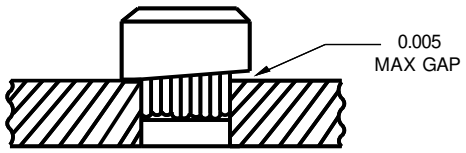
8.2 INSERTS AND STUDS

The following subheads cover the end product requirements for inserts and studs, whether they are pressed or welded into place.

8.2.1 Pressed or Welded Inserts

Pressed or welded inserts should be installed flush to the surface of the material. A gap of 0.005 inch is allowed provided that it does not extend for more than 1/3 of the circumference of the insert, and provided the bottom of the insert does not protrude from the bottom side of the material Figure 39.

Figure 39: Insert Head Gap



8.2.1.1 Pressed Inserts

Pressed inserts must be pressed into sharp-edged holes. The burrs must not be removed, since burr removal results in the possibility of not leaving enough material to properly capture the part. The insert must not exhibit any looseness to the touch.

8.2.1.2 Flush Pressed Nuts

Flush pressed nuts must be flush +0, - 0.005 inch and shall not protrude from the bottom side of the material. In addition, the nut must be perpendicular to the sheet within a tolerance of ±5°.

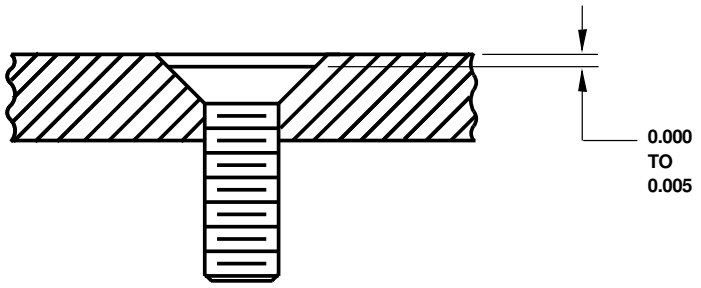
8.2.1.3 Protrusion Welded Inserts

Inserts which are protrusion welded into place shall not show evidence of heat distortion, and must exhibit proper weld penetration at all weld points.

8.2.2 Pressed Studs

Flush pressed studs must be pressed in place and be flush +0, - 0.005 inch. In addition, they must meet the minimum torque requirements specified in subhead 8.2.3.1 Figure 40.

Figure 40: Pressed Stud Depth



8.2.3 Welded Studs

Welded studs shall be tested by the following three methods:

a. Torque Test

b. Bend Test (Destructive Test)

c. Visual Examination

Partial or full separation of a stud from parent material during testing shall constitute a failure.

8.2.3.1 Torque Test

Using a torque wrench, a socket, and the test bracket shown in Figure 41, check the torque out value (the torque required to extract the stud) and compare the value obtained with Table 12. Figure 42 illustrates the correct method of performing the torque test.

Figure 41: Bracket for Torque Test

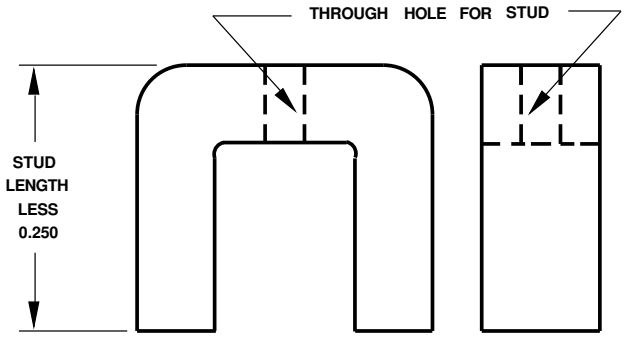


Figure 42: Torque Test

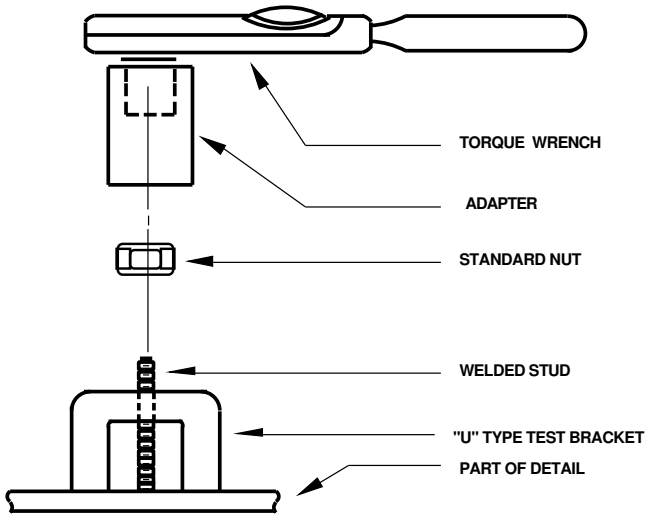


Table 12: Torque Test Torque Out Values

Thread Size	Copper Coated Steel (inch-pounds)	Aluminum (inch-pounds)
4-40	6.5	3.0
6-32	12.0	5.5
8-32	22.5	10.5
10-32	37.5	17.5
10-24	32.5	15.5
1/4-20	75.0	37.0
5/16-18	160.0	76.0

8.2.3.2 Bend Test

Using the tool of Figure 43 to perform the bend test in the manner shown in Figure 44, the stud should withstand a bend which results in permanent deformation of the stud (i.e. exceeds the yield point), before either the weld or the stud fractures.

Figure 43: Tool for Bend Test

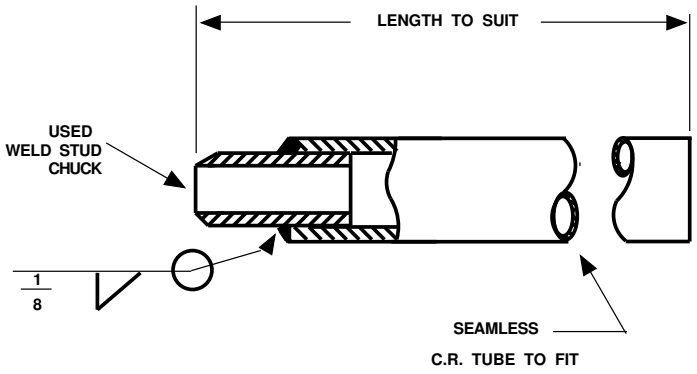
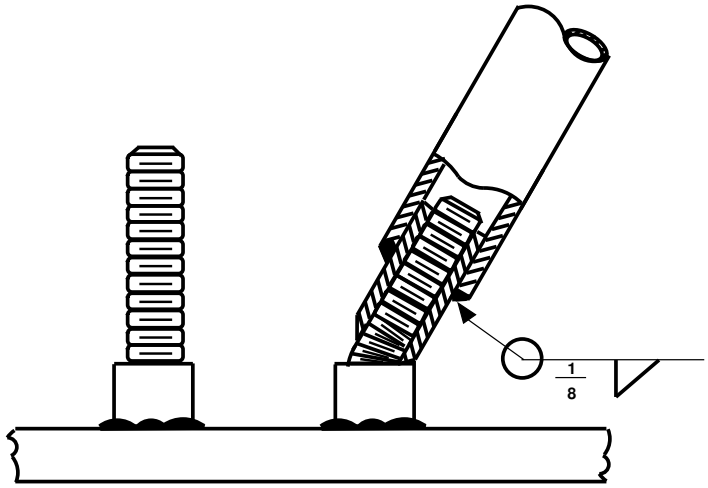


Figure 44: Bend Test



8.2.3.3 Visual Inspection

This test consists of an analysis of the appearance of the welded end of the stud. Figure 45 illustrates a properly welded stud; Figures 46 through 50 show examples of various incorrect stud welds.

Figure 45: Properly Welded

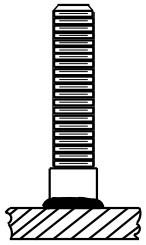


Figure 46: Plunge Too Short

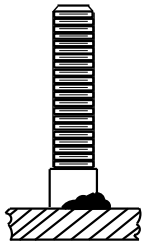


Figure 47: Hang-up

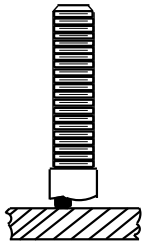


Figure 48: Poor Alignment

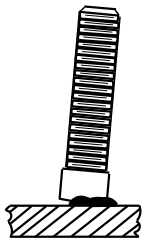


Figure 49: Insufficient Heat

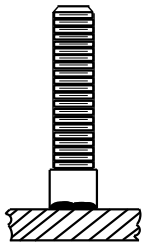
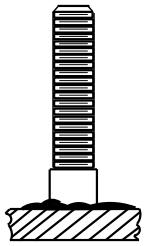


Figure 50: Excessive Heat



8.3 BOLTS AND SCREWS

The thread projection of a screw in a nut should, as a minimum, be flush to the nut and should not exceed four threads maximum beyond the surface of the nut. See *DEC STD 116-5 Workmanship Standards manual - Retaining Hardware and Mechanical fasteners*.

Flat-head screws shall be flush to the surface within ±1/64 inch.

Minimum thread engagement of screws in tapped holes should be a function of the material. For steel or hard brass, the engagement should be equal to or greater than the nominal diameter. For plastics, the engagement should be twice the nominal diameter. For alumimum or magnesimum, the engagement should be 1.5 times the nominal diameter, with anti-seize compound used for aluminum.

8.4 WELDING, BRAZING, AND SOLDERING

There are three methods of joining two metals with heat, as follows:

a. Soldering is the joining of two materials where the filler melting point is below 800°F.

b. Brazing is the joining of two materials where the filler melting point is below that of the base materials, but above 800°F.

c. Welding is the joining of two materials where the base material and the filler melt at the same temperature. Welding includes all of the processes defined in this section.

8.4.1 Welding

This and all subsequent subheads focus on welding. The most commonly used types of welding are defined as follows:

a. Electric Arc Welding is the melting and subsequent fusion of the metallic joint by heating with an electric arc between an electrode(s) and the work, with or without filler material and pressure.

b. Gas Welding is when metals to be welded are melted by a gas, such as oxyacetylene (a mixture of oxygen and acetylene, stored in separate tanks and combined immediately prior to use). A filler may or may not be used.

c. Electron Beam Welding is when the workpiece is bombarded with electrons to vaporize the metal, followed by a melt and eventual weld.

d. Resistance Welding is when workpieces are joined by a combination of heat generated by electrical resistance and force exerted by the electrodes. Forms of resistance welding included are spot welding where welds are separated into individual spots formed by the electrodes, stitch welding which consists of a series of overlapping spot welds, and seam welding which is accomplished by running the parts to be joined between rollers which have a pulsing current.

8.4.2 Resistance Welding

8.4.2.1 Penetration

Weld penetration into each outer piece shall be not less than 20% of the thinner of the pieces being joined.

8.4.2.2 Indentation

The indentation of the spot shall not exceed 10% of the thickness of the material being joined.

8.4.2.3 Spot Weld Spacing

Spacing between individual spot welds in a row and between rows of spot welds shall be within ±25% of the spacing required by the drawing.

8.4.2.4 Sheet Separation

Separation between sheets shall not exceed 25% of the thickness of the thinnest sheet being joined or 0.015 inch, whichever is smaller.

8.4.2.5 Seam Weld Spacing

Spacing between parallel seam welds shall be within ±0.125 inch of the spacing required by the drawing.

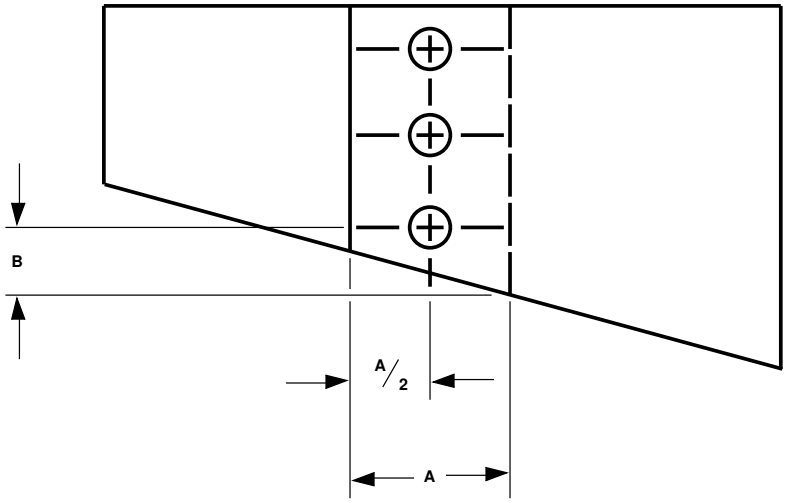
8.4.2.6 Length of Weld

The length of any type of weld shall not be less than that specified on the drawing.

8.4.2.7 Positioning

Welds shall be centered on the overlap (A) Figure 51. For spot welds, edge distance (B) shall be not less than half the minimum overlap. For seam and stitch welds, edge distance need not be observed provided there is no thinning, excessive expulsion, cracking, deformation, or buldging at the edge of the piece. Distance A/2 shall be within ±0.125 inch of the distance specified by the drawing.

Figure 51: Weld Overlap Spacing



8.4.2.8 Quality and Appearance

Resistance welds shall be sound, clean, and free from foreign materials and from imperfections detrimental to the performance of parts. Welds shall be free from excessive bulging, spitting, expulsion of metal, surface burning, and blown spots or pits in excess of 1/16 inch in diameter, unless otherwise permitted by the drawing. Welds specified by like symbols on drawings, and on a given combination of type and thickness of material, shall have a substantially uniform appearance. Figure 52 is not acceptable because the edge bulge is excessive and has caused the weld and the base metal to crack. Figure 53 is not acceptable because excess metal has been expelled, which has caused the weld to be deformed, as evidenced by excessive indentation and surface cracks. Figure 54 is not acceptable because the pit depth exceeds 1/16 inch and the weld contains cracks and burned metal.

Figure 52: Edge Bulge

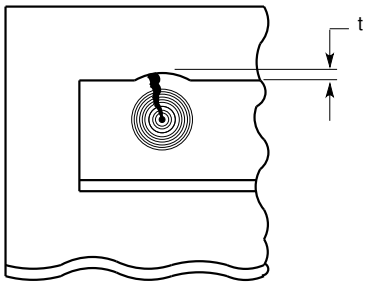


Figure 53: Excess Metal

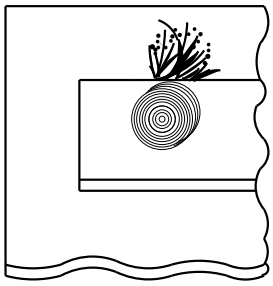
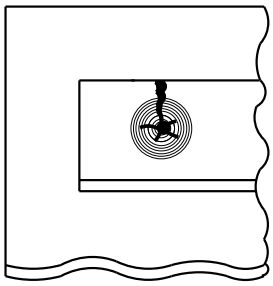


Figure 54: Pit and Cracks



8.4.3 Electric Arc and Gas Welding

Welds shall be sound, clean, and free from foreign materials and imperfections detrimental to the performance of parts. Welds shall be free from excessive burning, cratering, undercutting, and lack of weld penetration as described under the following subheads.

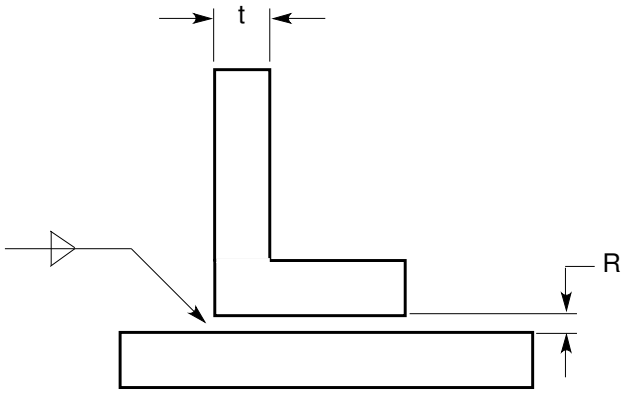
8.4.3.1 Tack Welds

If used, tack welds shall not be injurious to the parent metal and shall not affect the quality of the final weld. Tack welds shall be completely contained within the final weld, unless otherwise permitted.

8.4.3.2 Fit Up

Fit up of sheets shall be as follows. The root opening (R) - Figure 55 shall not exceed the tolerance corresponding to the thickness specified. For a thickness not exceeding 1/8 inch, (R) may be 1/32 inch; for a thickness exceeding 1/8 inch but not 3/8 inch, (R) may be 1/16 inch; and for a thickness exceeding 3/8 inch, (R) may be 1/8 inch. For automatic equipment, (R) may be 10% of the thickness, but not exceeding 0.010 inch.

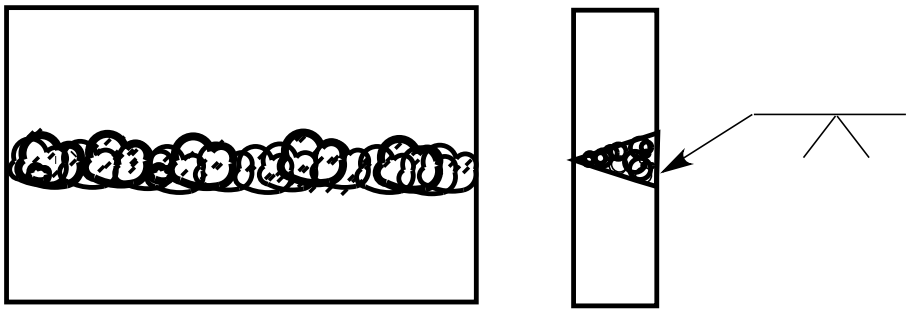
Figure 55: Fit Up



8.4.3.3 Burn Through

Burn through is acceptable, provided it does not cause craters and distortions in the parent metal. Figure 56 illustrates excessive burn through, which is beyond acceptability.

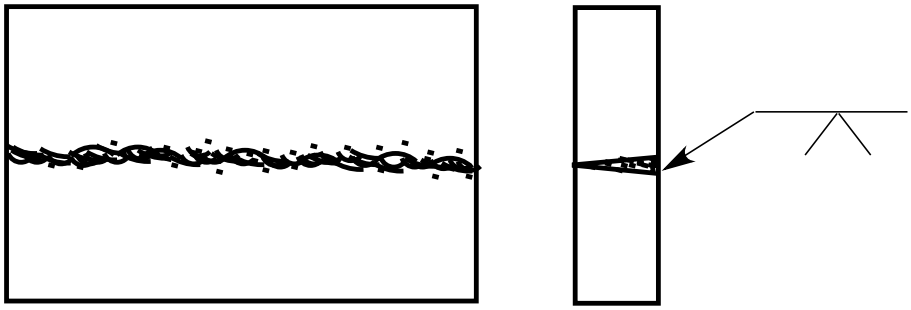
Figure 56: Burn Through



8.4.3.4 Penetration

Penetration shall be complete and uniform and shall not show evidence of the defects illustrated by Figure 57. The left part of Figure 57 illustrates failure of the weld metal to penetrate the butt joint; the right part illustrates possible failure of the weld metal to fuse with the parent metal, as evidenced by the apparent overlap and the irregular edge of the weld bead.

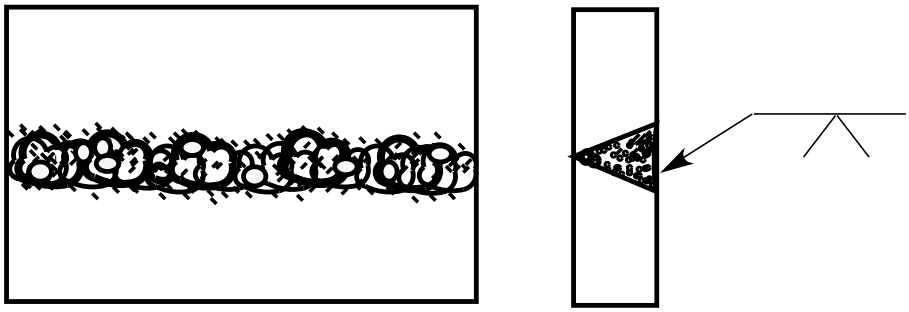
Figure 57: Inadequate Penetration



8.4.3.5 Porosity

Surface porosity is allowed, not exceeding 10% of the weld area. Figure 58 is not acceptable because the surface porosity diameters, in combinations, exceed 0.100 inch per lineal inch of weld, or 10% of the surface area of a lineal inch of weld.

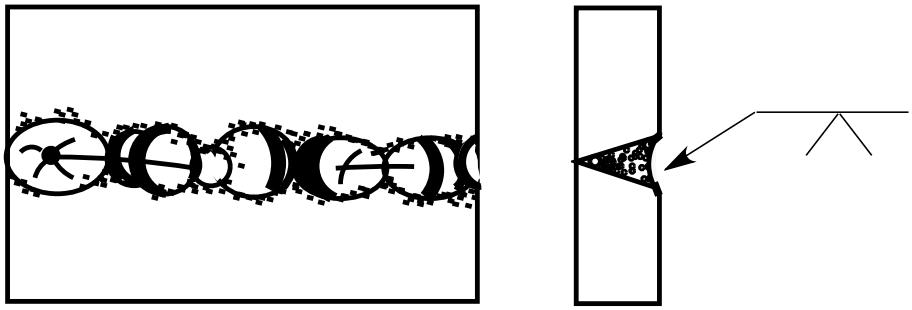
Figure 58: Excess Porosity



8.4.3.6 Cratering

Cratering is allowed if it does not exceed 10% of the thickness of the parent material, has not cracked the metal, and is not greater than the width of the weld bead. The weld illustrated in Figure 59 is not acceptable; it exceeds all three of the limitations.

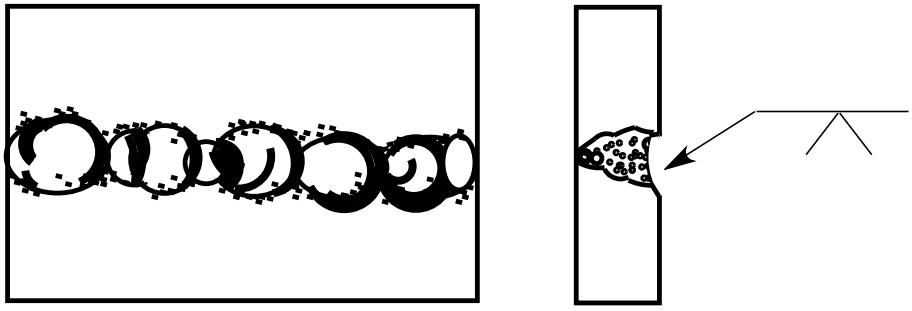
Figure 59: Excess Cratering



8.4.3.7 Undercut

Undercut is allowed if it does not exceed a depth of 10% of the parent material, is not greater than 1 inch in length, and multiple undercuts are not closer together than 4 inches. The weld illustration in Figure 60 is not acceptable; it exceeds all three of these limitations.

Figure 60: Excess Undercut



APPENDIX A REFERENCED DOCUMENTS

A.1 Other Digital Documents

Document Number	Document Title
76-65057-00	*Procedure for Processing Non-Conforming Material and In-Process Waivers*
76-65340-00	*Vendor Material Deviation Request*
ASP3700639000000	*General Purpose Metal Parts*
EL-00020-00	*DEC STD 020-0 Cast Metal Parts*
EL-00092-04	*DEC STD 092-4 Finish and Color Standard - Approved Finish Specifications*
EL-00116-05	*DEC STD 116-5 Workmanship Standards Manual - Retaining Hardware and Mechanical F asteners*
EL-00178-01	*DEC STD 178-1 Digital Marking Requirements for Piece Parts*
EL-00179-00	*DEC STD 179-0 Requirements for Specifying Raw Materials for Powder-Metal Parts*
EL-CE059-TM-002N	*Test method for Flammable Plastics*
EL-MF271-00	*Cherry "Q" Rivet (Self-Plugging) Procedure*
EL-SM119-01	*DEC STD 119 Digital Product Safety - Design*

A.2 Other Documents

Document Number	Document Title
ALUM. ASSOC.	*Standards for Aluminum Sand and Permanent Mold Castings*
AMER. DIE CAST.INST.	*Product Standard for Die Castings*
ANSI B1.1	*Threading*
ANSI B46.1	*Surface Finish*
ANSI Y14.11	*Plastics*
ANSI Y14.5	*Dimensioning and Tolerancing*
INVSTMNT. CAST. INST	*Investment Casting Handbook*
IRON CAST. SOCIETY	*Iron Castings Handbook*
MIL-STD-105	*Sampling Procedures and Tables for Inspection by Attributes*
SOC. PLASTICS IND.	*Plastics Engineering Handbook*
SOC.PLASTICS IND.	*Standards and Practices of Plastics Molders and Plastics Molded Parts Buyers Guide*
UL 94	*Standard Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

A.3 Ordering Information

Following are the sources for documents not available from Standards and Methods Control.

Copies of A-SP-3700639-0-0 may be obtained from any Microfilm Reference Library (35-mm aperture card tubs).

Copies of the UL Publication may be purchased from Underwriters Laboratories (UL), Publications Stock, 33 Pfingsten Road, Northbrook, IL 60062, telephone (312) 272-8800, x2612 or x2622.

Copies of the ADCI Standards may be purchased from the American Die Casting Institute at 366 Madison Avenue, New York, NY 10017.

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